

WE CLAIM:

1. An alignment system for a lithographic apparatus, comprising:

a source of alignment radiation having a first wavelength and a second wavelength;

a detection system comprising a first wavelength channel arranged to receive alignment radiation from an alignment mark at said first wavelength and a second wavelength channel arranged to receive alignment radiation from said alignment mark at said second wavelength; and

a position determining unit in communication with said detection system,

wherein said position determining unit processes information from said first and second wavelength channels in combination to determine a position of said alignment mark based on one of information from said first wavelength channel, information from said second wavelength channel and combined information from said first and second wavelength channels according to a relative strength of said alignment radiation detected at said first wavelength to alignment radiation detected at said second wavelength.

2. An alignment system according to claim 1, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on a relative strength of said first signal to said second signal.

3. An alignment system according to claim 2, wherein the weight factor for said second wavelength channel is set to zero when a strength of said first signal relative to said second signal exceeds a predetermined threshold.

4. An alignment system according to claim 1, wherein said source of alignment radiation comprises a first laser that generates radiation at said first wavelength and a second laser that generates radiation at said second wavelength.

5. An alignment system according to claim 1, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on signal strengths of said first and second wavelength signals.

6. An alignment system according to claim 1, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength,

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, and

said position determining unit determines said position of said alignment mark based on said first and second wavelength signals with a first precision.

7. An alignment system according to claim 1, wherein said detection system further comprises a third signal channel at said first wavelength and a second diffraction order sub-beam at said first wavelength, and a fourth signal channel at said second wavelength and a second diffraction order sub-beam at said second wavelength, and

said position determining unit determines said position of said alignment mark based on said first and second wavelength signals with a second precision that is more precise than said first precision.

8. An alignment system according to claim 1, wherein said first wavelength channel of said detection system corresponds to a first diffraction

order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, a value of said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

9. An alignment system according to claim 2, wherein said position determining unit processes said information from said first and second wavelength channels by further assigning a selectable parameter to combine information from said first and second wavelength signals.

10. An alignment system according to claim 9, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of reliability.

11. An alignment system according to claim 9, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of precision.

12. An alignment system according to claim 9, wherein said selectable parameter is determined prior to said assigning said weights.

13. An alignment system according to claim 9, wherein said selectable parameter is determined after to said assigning said weights.

14. An alignment system according to claim 2, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold

value, said weighting factors being constrained to be within a range from zero to one, inclusive.

15. An alignment system according to claim 14, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

16. An alignment system according to claim 14, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

17. An alignment system according to claim 14, wherein said selectable threshold value is an absolute threshold.

18. An alignment system according to claim 16, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

19. An alignment system according to claim 2, wherein said weighting factors assigned to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

20. An alignment system according to claim 19, wherein said weighting factors of said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

21. An alignment system according to claim 19, wherein said weighting factors assigned to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

22. An alignment system according to claim 1, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on at least one measurable quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter mcc is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, minirepro is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the

alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

23. An alignment system according to claim 2, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

24. A lithographic apparatus, comprising:

an illumination system;

a substrate stage assembly arranged in a radiation path of illumination radiation from said illumination system;

a reticle stage assembly arranged in said radiation path of said illumination radiation between said illumination system and said substrate stage assembly;

a projection system arranged between said reticle stage assembly and said substrate stage assembly; and

an alignment system arranged proximate at least one of said substrate stage assembly and said reticle stage assembly,

wherein said alignment system comprises:

a source of alignment radiation having a first wavelength and a second wavelength;

a detection system comprising a first wavelength channel arranged to receive alignment radiation from an alignment mark at said first wavelength and a second wavelength channel arranged to receive alignment radiation from said alignment mark at said second wavelength channel; and

a position determining unit in communication with said detection system,

wherein said position determining unit processes information from said first and second wavelength channels in combination to determine a position of said alignment mark based on one of information from said first wavelength channel, information from said second wavelength channel and combined information from said first and second wavelength channels according to a relative strength of said alignment radiation detected at said first wavelength to alignment radiation detected at said second wavelength.

25. A lithographic apparatus according to claim 24, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on the relative strength of said first signal to said second signal.

26. A lithographic apparatus according to claim 25, wherein the weight factor for said second channel is set to zero when a strength of said first signal relative to said second signal exceeds a predetermined threshold.

27. A lithographic apparatus according to claim 24, wherein said source of alignment radiation comprises a first laser that generates radiation at a first wavelength and a second laser that generates radiation at a second wavelength.

28. A lithographic apparatus according to claim 24, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on signal strengths of said first and second wavelength signals.

29. A lithographic apparatus according to claim 24, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength,

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, and

said position determining unit determines said position of said alignment mark based on said first and second wavelength signals with a first precision.

30. A lithographic apparatus according to claim 24, wherein said detection system further comprises a third signal channel at said first wavelength and a second diffraction order sub-beam at said first wavelength, and a fourth signal channel at said second wavelength and a second diffraction order sub-beam at said second wavelength, and

said position determining unit determines said position of said alignment mark based on said first and second wavelength signals with a second precision that is more precise than said first precision.

31. A lithographic apparatus according to claim 24, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, a value of said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

32. A lithographic apparatus according to claim 25, wherein said position determining unit processes said information from said first and second wavelength channels by further assigning a selectable parameter to combine information from said first and second wavelength signals.

33. A lithographic apparatus according to claim 32, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of reliability.

34. A lithographic apparatus according to claim 32, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of precision.

35. A lithographic apparatus according to claim 32, wherein said selectable parameter is determined prior to said assigning said weights.

36. A lithographic apparatus according to claim 32, wherein said selectable parameter is determined after to said assigning said weights.

37. A lithographic apparatus according to claim 25, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold value, said weighting factors being constrained to be within a range from zero to one, inclusive.

38. A lithographic apparatus according to claim 37, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

39. A lithographic apparatus according to claim 37, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

40. A lithographic apparatus according to claim 37, wherein said selectable threshold value is an absolute threshold.

41. A lithographic apparatus according to claim 39, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

42. A lithographic apparatus according to claim 25, wherein said weighting factors assigned to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

43. A lithographic apparatus according to claim 42, wherein said weighting factors of said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

44. A lithographic apparatus according to claim 42, wherein said weighting factors assigned to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

45. A lithographic apparatus according to claim 24, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on at least one measurable

quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter mcc is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, minirepro is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

46. A lithographic apparatus according to claim 25, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

47. A method of detecting an alignment mark on a substrate, comprising:

irradiating said alignment mark with alignment radiation that has at least two different illumination wavelengths;

detecting radiation from said alignment mark at a first wavelength of said at least two different illumination wavelengths and outputting a first wavelength signal;

detecting radiation from said alignment mark at a second wavelength of said at least two different illumination wavelengths and outputting a second wavelength signal; and

determining a position of said alignment mark based on one of said first wavelength signal, said second wavelength signal and a combination of said first and second wavelength signals according to a relative strength of said first wavelength signal to said second wavelength signal.

48. A method of detecting an alignment mark on a substrate according to claim 47, further comprising:

determining a first signal strength of said first signal; and

determining a second signal strength of said second signal,

wherein said determining a position of said alignment mark based on said first and second wavelength signals comprises assigning weighting factors to said first and second wavelength signals that depend on said first and second signal strengths.

49. A method of detecting an alignment mark on a substrate according to claim 47, wherein said detecting radiation from said alignment mark at said first wavelength of said at least two different illumination wavelengths comprises detecting a first diffraction order sub-beam at said first wavelength,

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a first diffraction order sub-beam at said second wavelength, and

said determining said position of said alignment mark based on said first and second wavelength signals comprises determining said position with a first precision.

50. A method of detecting an alignment mark on a substrate according to claim 49, wherein said detecting radiation from said alignment mark at said first wavelength of said at least two different illumination wavelengths comprises detecting a second diffraction order sub-beam at said first wavelength,

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a second diffraction order sub-beam at said second wavelength, and

said determining said position of said alignment mark based on said first and second wavelength signals comprises determining said position with a second precision that is more precise than said first precision.

51. A method of detecting an alignment mark on a substrate according to claim 47, wherein said detecting radiation from said alignment mark at said first wavelength of said at least two different illumination wavelengths comprises detecting a diffraction order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a diffraction order sub-beam at said second wavelength, a value of

said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

52. A method of detecting an alignment mark on a substrate according to claim 48, wherein said determining a position of said alignment mark based on said first and second wavelength signals further comprises assigning a selectable parameter to combine information from said first and second wavelength signals.

53. A method of detecting an alignment mark on a substrate according to claim 52, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of reliability.

54. A method of detecting an alignment mark on a substrate according to claim 52, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of precision.

55. A method of detecting an alignment mark on a substrate according to claim 52, wherein said selectable parameter is determined prior to said assigning said weights.

56. A method of detecting an alignment mark on a substrate according to claim 52, wherein said selectable parameter is determined after said assigning said weights.

57. A method of detecting an alignment mark on a substrate according to claim 48, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold value, said weighting factors being constrained to be within a range from zero to one, inclusive.

58. A method of detecting an alignment mark on a substrate according to claim 57, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

59. A method of detecting an alignment mark on a substrate according to claim 57, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

60. A method of detecting an alignment mark on a substrate according to claim 57, wherein said selectable threshold value is an absolute threshold.

61. A method of detecting an alignment mark on a substrate according to claim 59, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

62. A method of detecting an alignment mark on a substrate according to claim 48, wherein said assigning weighting factors to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

63. A method of detecting an alignment mark on a substrate according to claim 62, wherein said weighting factors to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

64. A method of detecting an alignment mark on a substrate according to claim 62, wherein said assigning weighting factors to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

65. A method of detecting an alignment mark on a substrate according to claim 47, further comprising:

determining a first signal strength of said first signal; and

determining a second signal strength of said second signal,

wherein said determining a position of said alignment mark based on said first and second wavelength signals comprises assigning weighting factors to said first and second wavelength signals that depend on at least one measurable quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter mcc is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, minirepro is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the

various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

66. A method of detecting an alignment mark on a substrate according to claim 48, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

67. A method of determining an alignment grid on a substrate, comprising

irradiating a plurality of alignment marks with alignment radiation that has at least two different wavelengths;

detecting radiation from each of said plurality of alignment marks at a first wavelength of said at least two different illumination wavelengths;

detecting radiation from each of said plurality of alignment marks at a second wavelength of said at least two different illumination wavelengths; and

determining said alignment grid based on information from said detecting at said first and second illumination wavelengths.

68. A method of determining an alignment grid according to claim 67, wherein said detecting comprises detecting radiation from an alignment mark from said plurality of alignment marks at a first wavelength of said at least two different illumination wavelengths and outputting a first wavelength signal;

detecting radiation from said alignment mark at a second wavelength of said at least two different illumination wavelengths and outputting a second wavelength signal; and

determining alignment grid parameters based on at least said first and second wavelength signals.

69. A method of determining an alignment grid according to claim 68, further comprising:

determining a first signal strength of said first signal; and

determining a second signal strength of said second signal,

wherein said determining alignment grid parameters based on said first and second wavelength signals comprises assigning weighting factors to said first and second wavelength signals that depend on said first and second signal strengths.

70. A method of determining an alignment grid according to claim 68, wherein said detecting radiation from said alignment mark at said first wavelength of said at least two different illumination wavelengths comprises detecting a first diffraction order sub-beam at said first wavelength,

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a first diffraction order sub-beam at said second wavelength, and

said determining said alignment grid parameters based on said first and second wavelength signals comprises determining said alignment grid parameters with a first precision.

71. A method of determining an alignment grid according to claim 70, wherein said detecting radiation from said alignment mark at said first

wavelength of said at least two different illumination wavelengths comprises detecting a second diffraction order sub-beam at said first wavelength,

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a second diffraction order sub-beam at said second wavelength, and

said determining said alignment grid parameters based on said first and second wavelength signals comprises determining said alignment grid parameters with a second precision that is more precise than said first precision.

72. A method of determining an alignment grid according to claim 68, wherein said detecting radiation from said alignment mark at said first wavelength of said at least two different illumination wavelengths comprises detecting a diffraction order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said detecting radiation from said alignment mark at said second wavelength of said at least two different illumination wavelengths comprises detecting a diffraction order sub-beam at said second wavelength, a value of said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

73. A method of determining an alignment grid according to claim 69, wherein said determining alignment grid parameters based on said first and second wavelength signals further comprises assigning a selectable parameter to combine information from said first and second wavelength signals.

74. A method of determining an alignment grid according to claim 73, wherein said selectable parameter eliminates information from said first wavelength signal from said determination of said alignment grid parameters

when said first wavelength signal fails to satisfy a selectable level of reliability.

75. A method of determining an alignment grid according to claim 73, wherein said selectable parameter eliminates information from said first wavelength signal from said determination of said alignment grid parameters when said first wavelength signal fails to satisfy a selectable level of precision.

76. A method of determining an alignment grid according to claim 73, wherein said selectable parameter is determined prior to said assigning said weights.

77. A method of determining an alignment grid according to claim 73, wherein said selectable parameter is determined after said assigning said weights.

78. A method of determining an alignment grid according to claim 69, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold value, said weighting factors being constrained to be within a range from zero to one, inclusive.

79. A method of determining an alignment grid according to claim 78, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

80. A method of determining an alignment grid according to claim 78, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

81. A method of determining an alignment grid according to claim 78, wherein said selectable threshold value is an absolute threshold.

82. A method of determining an alignment grid according to claim 80, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

83. A method of determining an alignment grid according to claim 69, wherein said assigning weighting factors to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

84. A method of determining an alignment grid according to claim 83, wherein said weighting factors to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

85. A method of determining an alignment grid according to claim 83, wherein said assigning weighting factors to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

86. A method of determining an alignment grid according to claim 68, further comprising:

determining a first signal strength of said first signal; and

determining a second signal strength of said second signal,

wherein said determining alignment grid parameters based on said first and second wavelength signals comprises assigning weighting factors to said first and second wavelength signals that depend on at least one measurable quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter mcc is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, minirepro is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

87. A method of determining an alignment grid according to claim 69, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

88. A method of determining an alignment grid according to claim 68, further comprising using at least one of grid residuals, non-orthogonality, an X-Y expansion difference and wafer expansion in the said determination of said alignment grid,

wherein grid residuals are the deviations from the measured alignment mark position to the fitted wafer grid, non-orthogonality and X-Y expansion difference are both measures of the deformation of the wafer, and wafer expansion is a measure of the expansion of the wafer.

89. A method of determining an alignment grid according to claim 68, further comprising storing information from said alignment grid parameters obtained for a first substrate.

90. A method of determining an alignment grid according to claim 89, further comprising retrieving said information from said alignment grid parameters obtained for a first substrate in said determining alignment grid parameters for a second substrate.

91. An alignment system for a lithographic apparatus, comprising:

a source of alignment radiation having a first wavelength and a second wavelength;

a detection system comprising a first wavelength channel arranged to receive alignment radiation from an alignment mark at said first wavelength and a second wavelength channel arranged to receive alignment radiation from said alignment mark at said second wavelength; and

a position determining unit in communication with said detection system,

wherein said position determining unit processes information from said first and second wavelength channels in combination to determine an alignment grid based on at least one of information from said first wavelength channel, information from said second wavelength channel and combined information from said first and second wavelength channels according to a relative strength of said alignment radiation detected at said first wavelength to alignment radiation detected at said second wavelength.

92. An alignment system according to claim 91, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on a relative strength of said first signal to said second signal.

93. An alignment system according to claim 92, wherein the weight factor for said second wavelength channel is set to zero when a strength of said first signal relative to said second signal exceeds a predetermined threshold.

94. An alignment system according to claim 91, wherein said source of alignment radiation comprises a first laser that generates radiation at said first wavelength and a second laser that generates radiation at said second wavelength.

95. An alignment system according to claim 91, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on signal strengths of said first and second wavelength signals.

96. An alignment system according to claim 91, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength,

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, and

said position determining unit determines said alignment grid based on said first and second wavelength signals with a first precision.

97. An alignment system according to claim 91, wherein said detection system further comprises a third signal channel at said first wavelength and a second diffraction order sub-beam at said first wavelength, and a fourth signal channel at said second wavelength and a second diffraction order sub-beam at said second wavelength, and

said position determining unit determines said alignment grid based on said first and second wavelength signals with a second precision that is more precise than said first precision.

98. An alignment system according to claim 91, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, a value of said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

99. An alignment system according to claim 92, wherein said position determining unit processes said information from said first and second wavelength channels by further assigning a selectable parameter to combine information from said first and second wavelength signals.

100. An alignment system according to claim 99, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of reliability.

101. An alignment system according to claim 99, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of precision.

102. An alignment system according to claim 99, wherein said selectable parameter is determined prior to said assigning said weights.

103. An alignment system according to claim 99, wherein said selectable parameter is determined after to said assigning said weights.

104. An alignment system according to claim 92, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold value, said weighting factors being constrained to be within a range from zero to one, inclusive.

105. An alignment system according to claim 104, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

106. An alignment system according to claim 104, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

107. An alignment system according to claim 104, wherein said selectable threshold value is an absolute threshold.

108. An alignment system according to claim 106, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

109. An alignment system according to claim 92, wherein said weighting factors assigned to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

110. An alignment system according to claim 109, wherein said weighting factors of said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

111. An alignment system according to claim 109, wherein said weighting factors assigned to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

112. An alignment system according to claim 91, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on at least one measurable quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal

envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter *mcc* is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, *minirepro* is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

113. An alignment system according to claim 92, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

114. A lithographic apparatus, comprising:

an illumination system;

a substrate stage assembly arranged in a radiation path of said source of illumination radiation;

a reticle stage assembly arranged in said radiation path of said source of illumination radiation between said source and said substrate stage assembly;

a projection system arranged between said reticle stage assembly and said substrate stage assembly; and

an alignment system arranged adjacent to said projection system and proximate said substrate stage assembly,

wherein said alignment system comprises:

a source of alignment radiation having a first wavelength and a second wavelength;

a detection system comprising a first wavelength channel arranged to receive alignment radiation from an alignment mark at said first wavelength and a second wavelength channel arranged to receive alignment radiation from said alignment mark at said second wavelength channel; and

a position determining unit in communication with said detection system,

wherein said position determining unit processes information from said first and second wavelength channels in combination to determine an alignment grid based on one of information from said first wavelength channel, information from said second wavelength channel and combined information from said first and second wavelength channels according to a

relative strength of said alignment radiation detected at said first wavelength to alignment radiation detected at said second wavelength.

115. A lithographic apparatus according to claim 114, wherein said position determining unit is constructed to process said information from said first and second wavelength channels by weighting first and second signals from said first and second wavelength channels with factors that depend on the relative strength of said first signal to said second signal.

116. A lithographic apparatus according to claim 115, wherein the weight factor for said second channel is set to zero when a strength of said first signal relative to said second signal exceeds a predetermined threshold.

117. A lithographic apparatus according to claim 114, wherein said source of alignment radiation comprises a first laser that generates radiation at a first wavelength and a second laser that generates radiation at a second wavelength.

118. A lithographic apparatus according to claim 114, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on signal strengths of said first and second wavelength signals.

119. A lithographic apparatus according to claim 114, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength,

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, and

said position determining unit determines said alignment grid based on said first and second wavelength signals with a first precision.

120. A lithographic apparatus according to claim 114, wherein said detection system further comprises a third signal channel at said first wavelength and a second diffraction order sub-beam at said first wavelength, and a fourth signal channel at said second wavelength and a second diffraction order sub-beam at said second wavelength, and

said position determining unit determines said alignment grid based on said first and second wavelength signals with a second precision that is more precise than said first precision.

121. A lithographic apparatus according to claim 114, wherein said first wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said first wavelength, a value of said diffraction order sub-beam at said first wavelength being dynamically selected based on processing said substrate had undergone, and

said second wavelength channel of said detection system corresponds to a first diffraction order sub-beam at said second wavelength, a value of said diffraction order sub-beam at said second wavelength being dynamically selected based on processing said substrate had undergone.

122. A lithographic apparatus according to claim 115, wherein said position determining unit processes said information from said first and second wavelength channels by further assigning a selectable parameter to combine information from said first and second wavelength signals.

123. A lithographic apparatus according to claim 122, wherein said selectable parameter eliminates information from said first wavelength signal from said position determination when said first wavelength signal fails to satisfy a selectable level of reliability.

124. A lithographic apparatus according to claim 122, wherein said selectable parameter eliminates information from said first wavelength signal

from said determination of said alignment grid when said first wavelength signal fails to satisfy a selectable level of precision.

125. A lithographic apparatus according to claim 122, wherein said selectable parameter is determined prior to said assigning said weights.

126. A lithographic apparatus according to claim 122, wherein said selectable parameter is determined after to said assigning said weights.

127. A lithographic apparatus according to claim 115, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable threshold value, said weighting factors being constrained to be within a range from zero to one, inclusive.

128. A lithographic apparatus according to claim 127, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a reflectivity of said substrate or a material on said substrate at each of said first and second wavelengths.

129. A lithographic apparatus according to claim 127, wherein said selectable threshold value is a relative threshold, relative to a selected value of a signal strength.

130. A lithographic apparatus according to claim 127, wherein said selectable threshold value is an absolute threshold.

131. A lithographic apparatus according to claim 129, wherein said weighting factors assigned to said first and second wavelength signals that depend on said first and second signal strengths further depend on a selectable absolute threshold value.

132. A lithographic apparatus according to claim 115, wherein said weighting factors assigned to said first and second wavelength signals are assigned such that said first wavelength signal is preferred over said second wavelength signal.

133. A lithographic apparatus according to claim 132, wherein said weighting factors of said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal subsequent to said second wavelength signal dominating over said first wavelength signal when said weighting factors were previously assigned such that said first wavelength signal was preferred over said second wavelength signal, leading to a hysteresis effect.

134. A lithographic apparatus according to claim 132, wherein said weighting factors assigned to said first and second wavelength signals are reassigned such that said second wavelength signal is preferred over said first wavelength signal based on predetermined criteria.

135. A lithographic apparatus according to claim 114, wherein said position determining unit is constructed to assign weight factors to said first and second wavelength channels that depend on at least one measurable quantity selected from the set of measurable quantities consisting of mcc, minirepro, signal-to-noise ratio, signal shape, signal envelope, focus, tilt, order channels position offset, wavelength channels position offset, shift between segments and coarse-fine position deviation,

wherein the parameter mcc is a multiple correlation coefficient indicating how well the measured signal resembles the signal expected for a perfect alignment mark, minirepro is a standard deviation of the aligned position of different sections or portions of an alignment measurement, indicating the accuracy of the aligned position, signal to noise ratio is the fitted signal divided by the relative level of noise across the spectrum of the

measured signal, while the signal shape is the relative level of a few discrete frequencies in this spectrum, generally at multiples of the base frequency; the signal envelope is variance of the signal strength during the measurement, the focus is the offset in wafer height during the measurement, the tilt is the angle between the wafer angle and the detector angle during the measurement, order channels position offset is the measured difference in aligned position of the various channels of one wavelength, the wavelength channels position offset is the measured difference in aligned position of the various wavelength channels, the shift between segments is the measured difference in aligned position of the various segments of a multi segmented alignment mark, and the coarse-fine position deviation is the difference between the position of the alignment marks in the fine phase with respect to their expected position based on alignment mark measurements in the coarse phase.

136. A lithographic apparatus according to claim 115, wherein said weighting factors assigned to said first and second wavelength signals are selected in accordance with a diffraction order that is detected.

137. A lithographic apparatus, comprising:

an illumination system;

a substrate stage assembly moveable between a radiation path of illumination radiation from said illumination system and a measurement location;

a reticle stage assembly arranged in said radiation path of said illumination radiation between said illumination system and said substrate stage assembly;

a projection system arranged between said reticle stage assembly and said substrate stage assembly; and

an alignment system located in said measurement location so as to be proximate said substrate stage assembly when said substrate stage assembly is in said measurement location,

wherein said alignment system comprises:

a source of alignment radiation having a first wavelength and a second wavelength;

a detection system comprising a first wavelength channel arranged to receive alignment radiation from an alignment mark at said first wavelength and a second wavelength channel arranged to receive alignment radiation from said alignment mark at said second wavelength channel; and

a position determining unit in communication with said detection system,

wherein said position determining unit processes information from said first and second wavelength channels in combination to determine a position of said alignment mark based on one of information from said first wavelength channel, information from said second wavelength channel and combined information from said first and second wavelength channels according to a relative strength of said alignment radiation detected at said first wavelength to alignment radiation detected at said second wavelength.